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REMOTE SENSING CENTER GRANT PROGRAM SUMMARY

NASA GRANT NGL 44-001-001

PROGRESS REPORT
February 1, 1976 — January 31, 1977

supported by
National Aeronautics and Space Administration



TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS



TECHNICAL ACTIVITY REPORT RSC-10

REMOTE SENSING CENTER
GRANT PROGRAM SUMMARY

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TABLE OF CONTENTS

	<u>Page</u>
TABLE OF CONTENTS	i
<u>SUMMARY</u>	1
<u>GRANT PROGRAM AT TEXAS A&M UNIVERSITY</u>	2
<u>AQUATIC PLANT MONITORING PROJECT</u>	8
<u>Project Objectives</u>	8
<u>Project Demonstration Area</u>	8
<u>People and Agencies Contacted</u>	9
<u>Activities to Date</u>	9
<u>Progress to Date</u>	10
<u>Accomplishments and Results</u>	11
<u>Future of the Project</u>	12
<u>COASTAL WETLANDS PROJECT</u>	14
<u>Project Objectives</u>	14
<u>Project Demonstration Area</u>	14
<u>People and Agencies Contacted</u>	15
<u>Activities to Date</u>	16
<u>Progress to Date</u>	17
<u>Accomplishments and Results</u>	17
<u>Future of the Project</u>	18
<u>APPLICATION OF LANDSAT DATA PRODUCTS FOR MANAGEMENT OF UNIVERSITY OF TEXAS LANDS</u>	20
<u>Project Objectives</u>	21

	<u>Page</u>
<u>Project Demonstration Areas</u>	22
<u>Activities and Progress to Date</u>	25
<u>Findings</u>	27
<u>Future of Project</u>	33
<u>COTTON ROOT ROT PROJECT</u>	34
<u>Background and Objectives</u>	34
<u>Project Demonstration Areas</u>	35
<u>Agencies and Others Contacted</u>	36
<u>Activities to Date</u>	37
<u>Progress to Date</u>	39
<u>Findings</u>	40
Five Cooperating Farms	40
Falls County Coverage	41
<u>Future of the Project</u>	44
<u>PEANUT DEFOLIATION AND YIELD ESTIMATION</u>	48
<u>Background and Objectives</u>	48
<u>Project Demonstration Areas</u>	48
<u>People and Agencies Contacted</u>	48
<u>Activities to Date</u>	49
<u>Progress to Date</u>	50
Results	51
<u>Defoliation vs. Reflectance</u>	51
<u>Defoliation vs. Yield</u>	54

	<u>Page</u>
<u>Aerial Photography</u>	54
<u>Future of the Project</u>	54
<u>CONCLUSION</u>	59

REMOTE SENSING CENTER
GRANT PROGRAM SUMMARY

NGL 44-001-001

February 1, 1976 - January 31, 1977

SUMMARY

The 1976 grant project activities resulted in completing work on the aquatic plant survey in Lake Livingston and in the Texas Gulf Coastal Wetlands, continuation of the Landsat rangeland management study in the University of Texas Lands, the successful first year survey of the mapping of cotton root rot in Falls and Bell Counties, Texas for use in disease control and the completion of the peanut foliar disease detection and yield estimation project.

The grant project continues to introduce remote sensing technology to users in Texas and other regions in the South through presentation of papers and briefings at technical and professional meetings.

The professional staff assembled to perform grant projects continues to function in direct response to NASA objectives and user interests while enjoying a very favorable reputation in technical accomplishments.

GRANT PROGRAM AT TEXAS A&M UNIVERSITY

The Texas A&M University NASA Grant Program in remote sensing has developed into a highly productive and effective applications oriented activity. Two primary types of projects are undertaken by the Remote Sensing Center in responding to industry and government requirements under funding by the NASA grant.

1. Demonstration Projects - investigations funded both by grant dollars and user agency dollars designed to utilize remote sensing technology that has been developed during an applications phase for practical data collection and resource management needs.

2. Applications Studies - investigations funded by the grant designed to adapt and test remote sensing technology for a practical problem in resource management.

Demonstration projects are conducted in order to introduce a specific remote sensing capability to an area of real user need and interest through cooperation and teaching of users in the operational realm. The 1976 grant project investigated two demonstration activities; an expansion of the aquatic plant monitoring project initiated in 1975 and a new project in evaluating green biomass productivity for rangeland management.

Two application studies were conducted in 1976; an evaluation of the use of color infrared aerial photography for detecting cotton root rot and peanut foliar disease.

The Microwave Program Development Project being conducted for the NASA Office of Applications was continued during 1976. The supporting technology projects were continued involving two very significant doctoral student studies dealing with development of basic models to describe the interaction mechanisms responsible for the sensitivity of active and passive microwave sensors to soil moisture. These projects have been phased out of the grant program as the students are completing their grant funded studies. These dissertations are:

"Volumetric Effects in the Depolarization of Electromagnetic Waves Scattered from Rough Surfaces," Andrew J. Blanchard
(Technical Report RSC-83)

"Thermal Microwave Emission from an Inhomogeneous Half-Space," Craig M. Hansen
(Technical Report RSC-84)

The 1977 work on the listed projects will demonstrate the use of remote sensing to the user in a way that he can efficiently incorporate the data produced into his management decision making and operational activities. Specific follow-on objectives are as listed below.

Project/User Agency

Aquatic plant monitoring using color infrared aerial photography. The primary user agency and co-funding agency will be the Corps of Engineers, responsible for nationwide programs in aquatic plant control. The test site has not yet been selected, but it will probably be a major Corps of Engineers reservoir in eastern Texas or eastern Oklahoma.

Objectives

Use seasonal aerial photography to map the species composition and the areal extent of aquatic plant concentrations for use in planning and implementing control measures. Monitor the effects of herbicide applications on various aquatic plant species.

Project/User Agency

Land use mapping in a coastal community using color infrared photography. The City of Galveston, the primary user agency, is also co-funding the project. In addition, the Sea Grant Program is providing some matching funds. The test area is Galveston Island, a part of the barrier island system lying along much of the Texas coast.

Objectives

Use seasonal aerial photography to document urban development and the remaining marsh and dune habitat on and adjacent to Galveston Island. Compile 1:24,000 scale baseline maps of the 1977 baseline condition of the island for use in devising a management plan for future development or conservation of existing natural areas.

Project/User Agency

Rangeland management on Texas lands, University of Texas Lands Leasing Department.

Objectives

Use Landsat digital data to map green biomass for improving range forage utilization and controlling noxious woody plants. Data will be used in the University of Texas Lands flexible leasing program.

Project/User Agency

Cotton disease detection, Cotton Incorporated, selected cooperating farmers, Texas Agricultural Extension Service.

Objectives

Demonstrate to commercial growers the usefulness of aerial color infrared photography for mapping cotton root rot disease infestations in Texas cotton growing areas. Diseased area maps are then used to guide the application of chemical treatments for control of root rot during off-season.

Project/User Agency

Peanut foliar disease detection, Texas Agricultural Extension Service, selected cooperating farmers.

Objectives

Complete data reduction and reporting to cooperators on usefulness of color infrared aerial photography for detecting peanut foliar disease.

Several of the grant funded projects have generated user interest and some financial support for continued development and operational use of techniques demonstrated by these projects.

The aquatic plant monitoring program is being used in a new application area with funds from a user agency (City of Galveston) as noted above. Several other preliminary inquiries have been made for use of the environmental mapping capabilities of the aquatic plant monitoring project.

The University of Texas Lands Leasing Department is providing funding support for associated graduate student research activities and is interested in implementing and funding a capability to continue the green biomass mapping study in future seasons.

In continuing the demonstration and applications efforts under NASA grant funding, the Remote Sensing Center is concentrating on those project areas where sincere user interest exists for direct funding of application of remote sensing technology for management and development planning and decision making.

AQUATIC PLANT MONITORING PROJECT

Project Objectives

The study provides periodic seasonal aerial photographic monitoring of the infestation and spread of a variety of noxious aquatic plants in Lake Livingston, Texas. Monitoring results are quickly furnished to the Trinity River Authority (TRA), the organization which manages Lake Livingston, as well as several other reservoirs lying along the Trinity River. The information alerts the TRA to new infestations and to the growth and spread of known infestations. Further, it documents the effectiveness of the TRA's ongoing herbicide application program. The work described served in part to satisfy the requirements for the Ph.D. degree for a graduate student. ("Monitoring Aquatic Plants in Texas," A.R. Benton, Jr., Technical Report RSC-76)

Project Demonstration Area

The majority of the monitoring work is being done on Lake Livingston, a 36,000 ha (90,000 acre) reservoir lying 100 km (62 miles) north of Houston, Texas. The dam was completed in the fall of 1969 and filled by the fall of 1971. The aquatic plant population in 1971 consisted of 20 ha (50 acres) of waterhyacinth. By the fall of 1974, it had grown to nearly 800 ha (2,000 acres) of waterhyacinth, duckweed, hydrilla and coontail. There are two continuing aquatic plant control programs on the lake: the Texas Parks and Wildlife Department (TP&WD) and

the TRA are both applying herbicides on waterhyacinth and hydrilla.

People and Agencies Contacted

The initial State of Texas contacts were in 1974 with the Texas Water Quality Board (TWQB) in Austin, Texas and the TRA's area supervisor at Livingston, Texas. The 1975 non-grant funding came from the TWQB and was administered by Dr. Richard Browning at TRA Headquarters in Arlington, Texas.

Because of a close working relationship between the TRA and the U. S. Army Corps of Engineers, the Corps became interested in the project during 1975. Non-grant funding in 1976 was from the Corps, while the working relationship continues to be maintained with the TRA at Lake Livingston. TWQB personnel attended all presentations.

Activities to Date

Photographic flights were made over Lake Livingston on 29 May, 23 July, 23 September, 4 November and 2 December 1976, and on 10 January 1977, providing a record of aquatic plant spread over a full growing season. The photography was done with a single 70 mm Hasselblad camera on Kodak Type 2443 Aerochrome infrared film. Color infrared had previously been found to be an

excellent medium for detecting and discriminating a variety of noxious aquatic species.

The film was developed in the Remote Sensing Center darkroom immediately after each photographic flight. Preliminary photoanalysis was carried out on the following day, and subsequent ground verification trips were undertaken usually within four or five days of the date of photography to verify the analytic findings. The TRA was advised immediately by telephone after each interpretation.

Progress to Date

Base maps were made from the 29 May photography, at several different scales, of seven separate infested areas on Lake Livingston. These maps were updated after each successive flight, thus providing a cartographic record of the patterns and trends in the seasonal growth of those species.

Interim reports were compiled for each monitoring sequence and furnished to the TRA and Corps of Engineers. At the time of this writing, all flights and ground truth trips have been made and five of the six seasonal maps have been compiled. Four of the six seasonal reports have been completed and forwarded. The fifth report is in preparation.

The sixth interim map and report, along with the 1976 season's final composite map and report, were completed in March 1977.

A major report, "Monitoring Aquatic Plants in Texas," Remote Sensing Center Technical Report RSC-76, covering nearly three years' research on aquatic plants, has already been compiled, printed and distributed to a number of interested organizations.

Accomplishments and Results

One of the key achievements of the 1976-1977 project year has been the development of photoanalytic and photocartographic procedures for detecting, discriminating and mapping the large number of aquatic plant communities now extant on Lake Livingston. Of particular help to the TRA has been the numerical listing of plant areal coverage, as of the time of each flight, on the updated thematic maps.

Aquatic plant control is a management problem, one which had previously suffered from the lack of timely and coherent management information as to the location of new outbreaks and the status of known infestations. From the TRA's standpoint, remote sensing imagery satisfies that specific requirement for management information.

Future of the Project

This was the final year of operations on Lake Livingston. The Trinity River Authority has been provided with a manual for doing their own remote sensing work on the lake in 1977, which is their present intention. They will be using a 70 mm camera system like the one used by the RSC study team.

The next, and probably the final step, will be the development of a prototype monitoring system for a state or federal agency. The 70 mm system developed and used on the Lake Livingston project is satisfactory for proof-of-concept and for monitoring on a single lake. For a large scale operation involving statewide coverage at minimum cost per hectare, a standard mapping format of 23 cm x 23 cm is needed.

The 1977 prototype development is being carried out on Robert S. Kerr Lake, a recently built Oklahoma reservoir with a surface area of some 17,000 hectares (42,000 acres), a size which is rather typical of the newer reservoirs in Oklahoma and east Texas. It has some very extensive infestations of Eurasian watermilfoil, a noxious, submersed aquatic weed. The Corps of Engineers will be conducting a major aquatic plant control test program on the lake during the summer and fall of 1977,

making it a near ideal locale for a test of the prototype photographic system.

Contact has been established with Mr. Louis Decell, Chief of the Aquatic Plant Research Branch of the Corps of Engineers' Waterways Experiment Station, concerning augmentation of financial support for the project, and with Mr. Loren Mason of the Corps' Tulsa District Office concerning boat transportation on the lake. Boat and personnel support have already been received from the Tulsa District and it appears that the Waterways Experiment Station will soon provide funding support as well.

COASTAL WETLANDS PROJECT

Project Objectives

This study, which covers seven critical estuaries along the central Texas coast, has been undertaken to provide the Texas Water Development Board (TWDB) with seasonal maps showing the identity and extent of the plant communities in the coastal wetlands.

The TWDB, which has the statutory responsibility for determining the impact of watershed management on the ecological environment of the estuaries receiving the managed inflows, required baseline descriptions of present conditions in those coastal areas. Color infrared aerial photography, undertaken periodically during the growing season, provides the necessary base data for compilation into baseline maps.

Project Demonstration Area

The project area is located in the central third of the Texas gulf coast. It includes the following seven deltas or embayments:

- the Colorado River delta from the Gulf of Mexico to 20 km inland,
- the Lavaca River delta from Lavaca Bay to 15 km inland,

- the west side of Pass Cavallo from the Gulf of Mexico to Port O'Connor,
- San Antonio Bay from Turnstake Island south-eastward to the Gulf of Mexico,
- The Guadalupe River delta from Foster Point to Green Lake,
- the vicinity of Aransas Pass, from the barrier island to the mainland, and
- Rincon Bayou, from Nueces Bay to 12 km inland.

These seven estuarine areas will be impacted in varying degrees by new reservoir construction in the near future. All of the marshlands are reasonably healthy and productive at the present time, although some appear to have been degraded to an extent by construction, by municipal and industrial effluents, or by a combination of the two.

People and Agencies Contacted

First contact was made with Mr. Jack Nelson of the Texas Water Development Board during the summer of 1975. Subsequent to a successful feasibility study in late summer of 1975, Mr. Nelson was instrumental in arranging for half of the funding for the 1976 project.

The balance of the 1976 non-grant funding was provided by Dr. Roy Hann, Director of Texas A&M's Center for Marine Resources and by Mr. Harry Whitmore, Associate Director of the Texas Engineering Experiment Station.

Presentations of project findings to the TWDB are regularly attended by officials from the Texas Water Quality Board, the Texas Parks and Wildlife Department and the Texas General Land Office, responsible for, respectively, estuarine water quality, coastal fisheries and coastal zone management.

Activities to Date

Photo flights were made over all seven areas in mid-May, late July, early October and late November of 1976, thus completing project photography for the 1976 growing season. Type 2443 color infrared film was used in a Wild RC-9 mapping camera with standard 23 cm x 23 cm format.

The film was developed commercially on a 48-hour turnaround. Preliminary photoanalysis was done prior to departure on ground truth work. Seven day ground truth trips followed, usually initiated within five days of the aerial photography. The main focus of the ground truth trips was verification of species identity and resolution of questions that arose during preliminary photoanalysis.

Progress to Date

Photographic and field data have been used to update the local 1:24,000 scale map base and to provide sequential maps showing the species makeup and the extent of the wetlands vegetation communities.

Interim narrative reports have been prepared for each photographic sequence. Report presentations are made in person at TWDB headquarters in Austin, Texas utilizing color slide copies of the original 23 cm x 23 cm imagery.

At present, all flights and ground truth trips have been made. All four interim reports have been completed and presented. The final project report is also underway and will be completed by the end of May 1977.

Accomplishments and Results

There is far more information on the sequential imagery than can be utilized within the scope of the present project. Of greatest immediate value to the TWDB has been the provision of maps showing which species are growing within the various wetlands areas, the acreage they occupy and the relative condition of the various communities. This information is in turn being fed into a mathematical

model which quantifies total marsh productivity under varying inflow conditions.

Of perhaps equal importance to the TWDB are the insights gained into the seasonal growth patterns and plant succession characteristics within the several wetlands areas under observation. It would appear that this project may be unique in the United States in that it permits documentation of seasonal trends and variability in the fragile coastal marshes.

In addition, the Texas General Land Office, the Texas Water Quality Board and the Texas Parks and Wildlife Department are discovering applications of the project data relevant to their own interests and responsibilities in the coastal zone.

Future of the Project

The 1976 season's work will conclude the project as it is now conceived by the TWDB. No approach has yet been made to the other interested state agencies concerning follow-on work in different coastal areas.

On the other hand, a closely related project is expected to be undertaken with and for the City of Galveston in 1977. The Galveston project will provide the city with baseline data with which to document a management plan

which will control the rate of future urban spread into the dune and marsh environment of Galveston Island. It appears that total financial support will be provided by the City of Galveston and by Sea Grant..

APPLICATION OF LANDSAT DATA PRODUCTS FOR MANAGEMENT OF UNIVERSITY OF TEXAS LANDS

A three year demonstration project was initiated in 1976 to implement the use of Landsat digital data products for managing University of Texas Lands. The Remote Sensing Center is using technology which it developed for analyzing and displaying Landsat MSS data to provide maps which will be used by University Lands personnel. The application of Landsat MSS data products is being evaluated based on the needs of University Lands personnel and the capabilities of Landsat data.

The University Lands consist of approximately 2.1 million acres of rangeland in the arid and semi-arid lands of west Texas. In 1969, the University of Texas System Board of Regents approved a policy requiring a conservation program for each grazing lease granted. All of the 133 grazing leases are required to operate under these programs. Currently, the Soil Conservation Service provides a service to the University by working with the individual leasees and developing conservation plans for each management unit.

The University Lands are presently leased on a per acre basis, as are most rangelands. A more equitable flexible leasing system has been developed and is based

on a charge per animal unit with some adjustment for fluctuating livestock prices. Under the flexible leasing system, livestock numbers will be adjusted semi-annually based on range condition and trend analysis. Monitoring the flexible leasing system will require more intensive vegetation inventories. To fulfill some of these information needs Mr. Billy Carr, University of Texas Land Agent, has requested that the Remote Sensing Center demonstrate their capabilities for providing Landsat MSS digital data products.

Project Objectives

The general objective of this three year demonstration project is to evaluate Landsat MSS digital data products for application in a flexible leasing and management system. These products are to be evaluated by University Lands Surface Leasing personnel and cooperating field scientists of the Soil Conservation Service.

The basic approach to this task is to 1) select demonstration sites, 2) define map products desired, 3) select and acquire optimum Landsat data sets, 4) generate the map products, 5) evaluate map accuracy with aerial photography and ground data and 6) provide the maps for user evaluation.

During the course of this project, species distribution and density maps for mesquite, juniper, creosote bush and other important brush and noxious weed species will be produced. The unique spectral signatures exhibited temporally by these species will be used for species separation. Range feed condition and ground cover will be mapped for selected critical dates. Preliminary soil maps will be produced for "uncharted" lands containing University property, and existing low intensity soil surveys will be improved for management planning uses.

Landsat-derived products produced during the first year include maps of mesquite and juniper distribution and density, and ground cover maps made from data collected during the peak of the 1976 growing season forage production period for a selected lease unit.

Project Demonstration Areas

The normal coverage of seven Landsat frames encompasses all of the University Lands in west Texas which are scattered from near San Angelo westward almost to El Paso (Figure 1).

To evaluate properly the applicability of the Landsat map products to the highly variable University

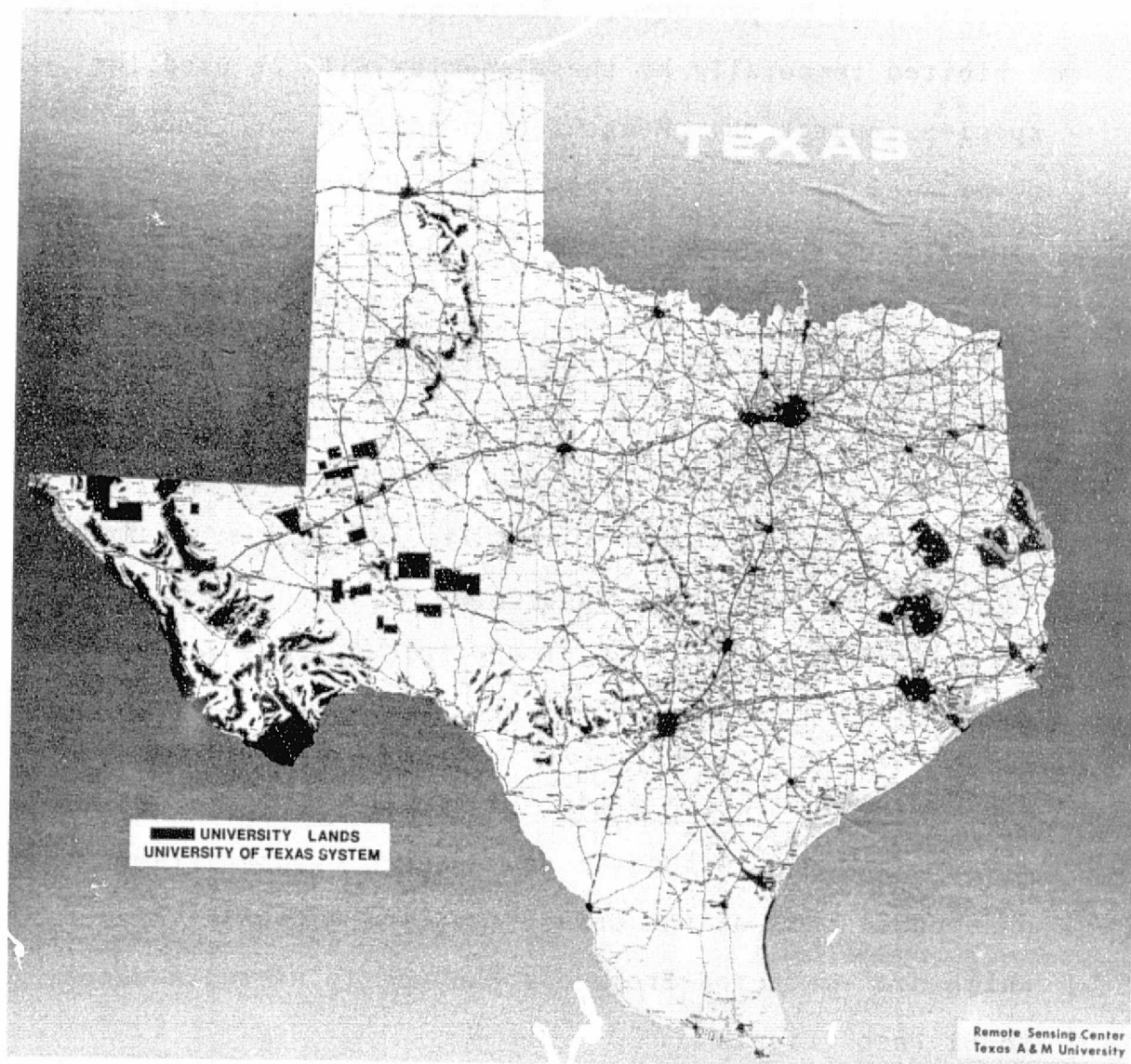


Figure 1. Location of the University Lands covering 2,074,636 acres in west Texas. These lands comprise 133 grazing lease units managed by 119 ranchers.

Lands, it was necessary to select demonstration areas that would provide a wide range of vegetation/soil types (range sites). Also, due to the very limited funding for this demonstration effort, it was necessary to coordinate closely this activity with field sampling activities for range condition and trend studies of the Range Science Department. The lease units selected, therefore, include the study sites in Reagan, Crane and Andrews Counties that are being monitored for changes in condition and trend.

During the first year of the study, most of the mapping activity has been concentrated on the Strauss Lease in Reagan County. This lease unit is the first to employ the new flexible leasing system. The Strauss Lease also contains a wide range of vegetation and soils, making it a rigorous "proving ground" for the pilot effort.

The 5,800 acre Strauss Lease is located approximately 5.5 miles south of Big Lake, Texas and two miles east of state highway 137. The management unit is divided into four pastures ranging in size from 1,163 acres to 1,559 acres. Range sites are primarily low, stony hills, loamy sites and valley sites. The low, stony hills have an overstory composed mainly of juniper with some mesquite and an understory dominated by perennial three-awn and

hairy tridens. The loamy sites are dominated by mesquite with grasses composed mainly of perennial three-awn with tobosagrass and buffalograss. Valley sites contain a mixture of mesquite and juniper with tobosagrass and buffalograss as understory dominants. Forty percent of the ranch has had brush control measures applied in the form of aerial spraying or chaining within the past eight years.

Activities and Progress to Date

The lease units to be used for this demonstration project were identified and located with respect to nominal Landsat frames. Medium scale (1:24,000) color infrared aerial photography was acquired for all lease units on June 16, 1976. Ground visits to the three selected sites were made at this time also. Color infrared aerial photographs at 1:8,000 scale were acquired of the Strauss Lease on September 21, 1976. These photographs are being used to verify the accuracy of the brush density and ground cover maps produced from Landsat MSS digital data.

The TAMU/RSC Landsat Browse Facility was used to select Landsat coverage that could be used to produce the desired map products. The Landsat computer compatible tapes (CCT's) to be used for mapping mesquite and juniper distribution and density were ordered and have been

received from the EROS Data Center. The June 1976 Landsat CCT's to be used for mapping forage volume were ordered and forage maps have been produced, but the tapes were received too recently for analyses of the map products to be completed at the time of this report.

Computer processing software has been developed to provide geometrically rectified computer greyscale printout maps of Landsat MSS digital data at 1:24,000 scale using a conventional impact printer. The data handling procedures have been validated with test runs for the Strauss Lease. Other techniques to provide map output products are also being developed, including a photo map from the Dynamic Color Display (DCD, a color coded vidicon screen display), and a rectified greymap of the data imaged on the DCD produced with a special printer/plotter.

Preliminary maps of brush distribution and density have been produced using the TVI6 parameter (developed during the TAMU Landsat-1 Great Plains Corridor investigation) for single dates independently selected to optimize the green biomass information content for a particular species.

Green biomass has been mapped on the Strauss Lease for the July 31, 1976 Landsat-1 overpass to demonstrate

this mapping technique and two alternative product formats. Figure 2 shows a rectified greyscale printout map with increments of green biomass using symbols selected to depict four levels of brush density. It is compared with a USGS topographic map at 1:24,000 scale, Figure 3 is a color coded display of the same data showing eight green biomass levels as photographed from the TAMU/RSC DCD. Validation maps being prepared from aerial photography are nearing completion at the time of this report.

A map of green biomass for June 29, 1976 (Figure 4) using a recently developed greymap technique was completed in time to include in this report.

"Applied Regional Monitoring of the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation in the Great Plains Corridor," by D.W. Deering, was a significant report resulting from work conducted under grant funding as partial fulfillment of requirements for a Ph.D. degree.

Findings

In order for Landsat data to be acceptable to most users, such as the University Lands and SCS personnel, the data must be presented as an easily interpretable, geometrically correct map of a convenient scale. Consequently, considerable effort on this project has been

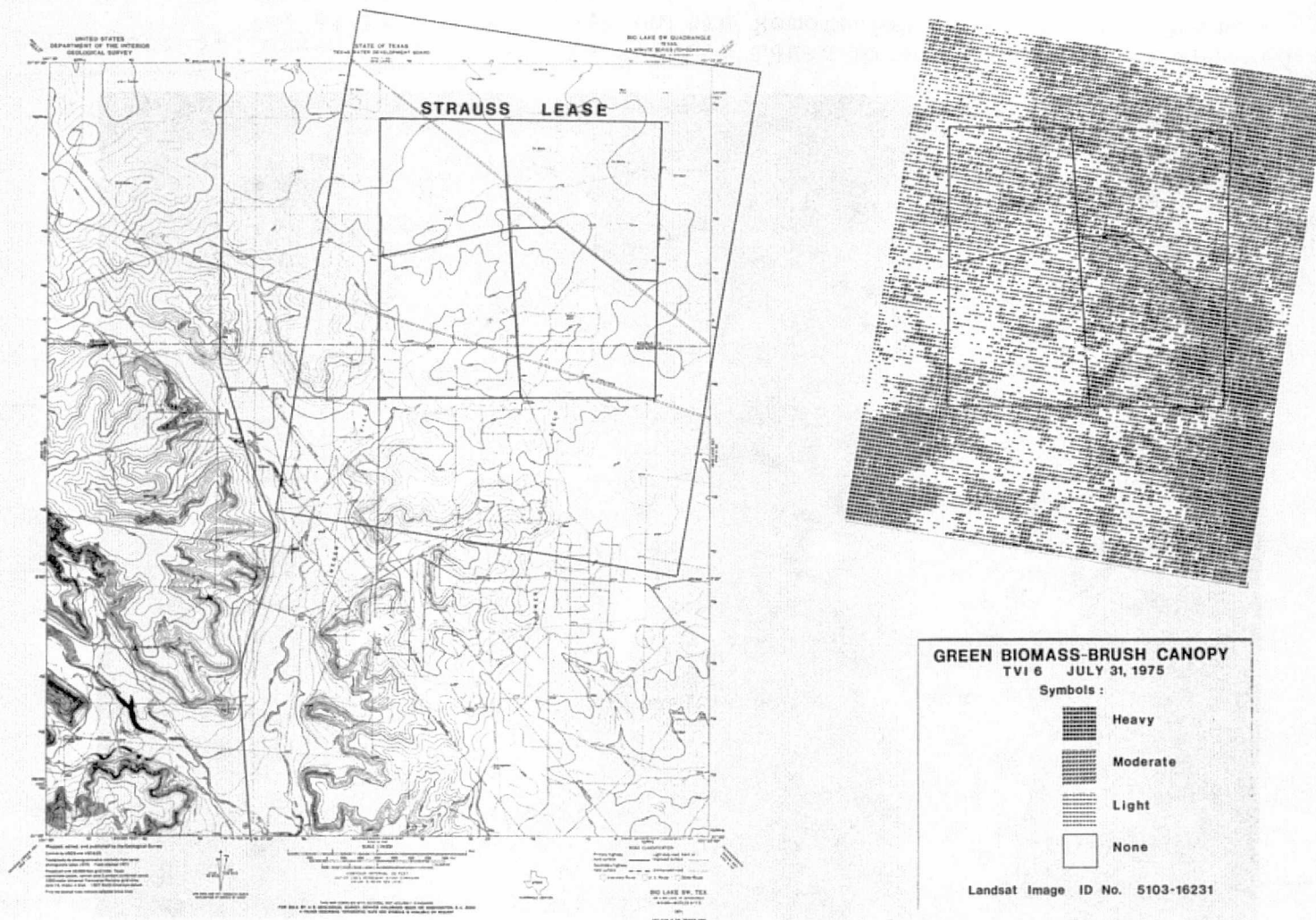


Figure 2. Four levels of brush canopy cover on the Strauss Lease on July 31, 1975 mapped from Landsat MSS data as the TVI6 parameter. The rectified greymap is compared with the corresponding USGS 1:24,000 scale topographic map.

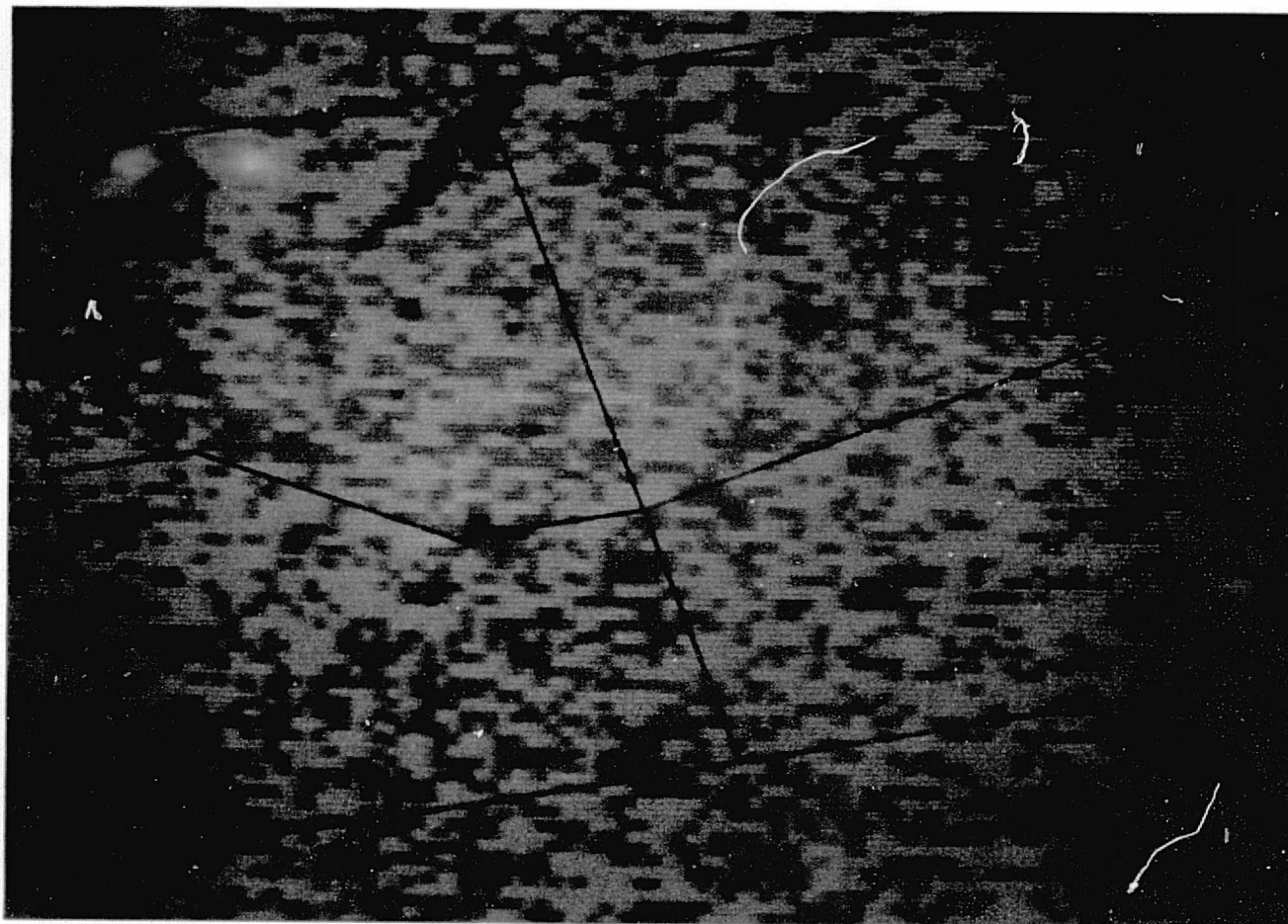


Figure 3. Green biomass on the Strauss Lease on July 31, 1975 displayed as eight color levels on the Remote Sensing Center's Dynamic Color Display system.



Figure 4. Geometrically rectified greymap of TVI6 depicting eight levels of green biomass on the Strauss Lease on June 29, 1976.

allocated to developing this capability for presenting the Landsat data. Computer software programs originally developed at GSFC were implemented to rectify the Landsat data. Additional software was developed to interface the rectified data with TAMU and RSC systems to generate output products. It was found that with the techniques used with the conventional impact printers having ten cells per inch and eight lines per inch, reasonably accurate 1:24,000 scale maps could be generated. For areas encompassing approximately ten square miles (26 square km), these maps were quite acceptable (see Figure 2). The most recent map products (see Figure 4) use a Versatec printer to produce a pixel matrix more similar to that of Landsat with a 10 x 7 matrix. These map products are more appealing due to the symbols used and are more accurate.

Figure 2 shows a long narrow valley site with a heavy infestation of brush in the southeast pasture of the Strauss Lease on July 31, 1975. Soil Conservation Service records confirm that this was an area of severe brush infestation. Their plan maps show that in December of the same year, the brush was removed from this area by chaining. Figure 4 shows this previously heavy mesquite area in the spring after chaining.

Green forage estimation for the Strauss Lease in June 1976 was necessarily delayed to the end of the

first year's activity because of the lag time in CCT data acquisition. The Landsat catalogs and preview microfilm have been received as much as four months after the date of acquisition by the satellite. Cloud coverage and MSS data quality cannot be determined adequately during this interim period. Consequently, Landsat data from retrospective product orders that are placed after microfilm evaluation are generally not received until six months after the date of acquisition by the satellite. The June 1976 Landsat CCT's were recently received and output products (see Figure 4) are being produced for evaluation.

Prior to the initiation of the second phase of the demonstration project, the following activities will be accomplished:

1. Mesquite and juniper cover maps showing critical levels of infestation will be verified with ground and aerial photo data for the Strauss Lease;

2. Green forage biomass calculations will be made for late June 1976 for the Strauss Lease by grazing units from the Landsat TVI6 map data and verified with ground measurements;

3. A plan for monitoring green biomass from Landsat for determining carrying capacity from Landsat data on University Lands will be outlined; and

4. These products will be provided to the land

agent and his associates to evaluate their usefulness for implementation in their management programs.

These evaluations should include a determination of what action could have been taken with the green forage biomass information had it been timely and what action can be taken with the mesquite and juniper map information.

Future of Project

During the second year (1977) of this demonstration project, mesquite and juniper will be mapped on the Crane and Andrews units that were selected in Phase I. These maps will also be verified by ground data and aerial photography. Green biomass will be mapped for the Crane and Andrews Lease units for verification of the technique for these types of range vegetation as was done for the Strauss Lease in Phase I. Work will be initiated to map the noxious creosote bush and the poisonous bitterweed species. An approach based on phenology and green biomass similar to that used for mesquite and juniper is proposed for mapping these species. In addition, in June 1977, the carrying capacity of the Strauss Lease will be determined from the Landsat data in as timely a manner as possible to provide the University Lands agent with the information needed to adjust the stocking rate in July based on the current (1977) year's forage production. This assumes that for this one time, a Landsat data set can be acquired from NASA within about a one week period from the date of acquisition.

COTTON ROOT ROT PROJECT

Background and Objectives

This project is designed to produce data from aerial photointerpretation on the location and extent of cotton root rot infestation for subsequent control by chemical soil additives. Aerial color infrared photos are to be taken during the growing season as a means to identify those areas infected with the disease. These photos are interpreted by project personnel who then provide annotated photographs to the county agents who cooperate with the individual farmers to identify diseased cotton fields. Soil samples are collected from infected areas prior to treatment with sodium fungicidal material. Chemical application occurs during the fall season after crop removal only on infected areas. Aerial photography will be taken during the subsequent cotton cropping season to determine the effectiveness of the soil treatment program for controlling cotton root rot. No effective alternative method exists for identifying the extent of infected crop areas.

Specific objectives are:

1. To delineate on photos diseased areas in cooperating farmers' fields. The farmers will treat the

areas in the off-season, and next crop year's photography will be used to evaluate the success of the treatment.

2. To assess the total disease affected cotton area in Falls County for the 1976 crop year.

Project Demonstration Areas

The area involved in the cotton root rot project encompasses all of Falls County, Texas and the eastern half of Bell County. Five cooperating farms within that area are involved in the delineation, treatment and follow-up evaluation of specific diseased fields.

According to a survey completed in 1976, the total area of the two counties are: Bell - 690,560 acres, Falls - 489,600 acres. Of these values, the total water area (of water bodies greater than 40 acres) are: Bell - 8,480 acres; Falls - 640 acres. Consequently, the total land areas of the counties are: Bell - 682, 112 acres; Falls - 488,960 acres.

The five cooperating farms differ in the number of fields and acreages being examined. Perkin's farm has six fields under study ranging from 23 to 55 acres in size. Collier's farm has five fields from 13 to 66 acres, while Ejem's has eight fields from 6 to 49 acres. Marek's has six fields from 10 to 35 acres and Cobb's has six fields which range from 12 to 80 acres.

Agencies and Others Contacted

During the period of this project to date (February 1976 - January 1977), the Remote Sensing Center made contact with the state, federal and industry offices involved: Texas Agricultural Extension Service, Texas Agricultural Experiment Station, Agricultural Stabilization and Conservation Service/USDA (ASCS), NASA/Johnson Space Center and Cotton Incorporated. Mr. Gilbert Wood of the Texas Agricultural Extension Service has been concerned with the role of the county agents in working with the cotton farmers of Bell and Falls Counties, Texas to apply the results of the aerial survey of infected areas. It has been arranged with Dr. Robert A. Spreen, State Executive Director of the ASCS, to deposit the aerial survey photo and map products in their offices in the formats they commonly use. ASCS is the contact point in Bell and Falls Counties for the TAES county agents and the individual farmers with whom they work. Mr. Leonard Ballenger and Mr. Bill Shaw of the NASA/JSC Earth Resources Program Office were apprised of the scope and timing of the project and alerted to the flight request submitted for high flight aerial photography between July 15 and August 15, 1976. Mr. Andy Anderson and Mr. Dave Whittle, JSC Mission Managers, were contacted about aerial photography details

and subsequently flew the missions. Dr. Wolfgang Wessling of Cotton Incorporated, the growers' association, agreed to support the soil sampling required before the treatment was applied. The five cooperating farmers are Mr. Shorty Perkins, Mr. W. C. Collier, Mr. Pete Ejems, Mr. Kenneth Marek and Mr. Leonard Cobb.

Activities to Date

The test area and flight lines were delineated. The NASA RB-57 acquired color IR photography of the entire area on two dates: August 4 and September 30, 1976. The RSC aircraft also acquired color IR photos twice at two larger scales (1:3,000 and 1:20,000) along several transects within the whole area. The RSC flights were between August 4 and September 7, 1976.

The RSC ground truth and liaison group consisted of two elements: a soil sampling group and an aerial survey group. The aerial survey personnel handled all remote sensing aspects of the ground data including flight line layout and photo distribution, while the soil sampling group was responsible for such tasks as taking soil samples within specified areas, analyzing them for presence of the fungi and prescribing treatment.

It was arranged for the ASCS office in Temple, Texas to archive the final photo products at their location. The ASCS personnel provide aid to the county agents and their farmer clients in locating and interpreting the photos.

Lab techniques for arriving at the final photo products to be archived are defined. A Bausch and Lomb Zoom Transfer Scope is an integral part of the processing.

It was determined that the percent of cotton acreage which was diseased could be found statistically by the use of a systematic sample using a dot grid.

Systematic sampling provides a useful alternative to other area determination techniques for several reasons. It is easier to perform, much less tedious and time consuming and, therefore, less subject to error. Also, as the systematic sample is less time consuming, it is less costly in terms of man hours and material. The sampling technique chosen, known as a one-in-k systematic sample, is one where a dot from the first k dots is randomly chosen and then every kth dot after that is chosen. The principle of a binomial test is used, i.e., the dot is on live vegetation or it is on dead vegetation. The percent of each class calculated then is thought of as percent live versus percent dead.

The practicality of the sampling technique is that it allows a smaller number of dots to be sampled than the total number which are needed to produce the exact answer. This number, $\underline{n}$, is related to the total number of dots, $\underline{N}$; the variance of the sample, $\underline{\sigma^2}$, the bound desired on the error of estimation, $\underline{B}$; and the confidence limits on these values expressed as their corresponding T values, $\underline{t}$; and may be expressed as

$$n = \frac{N\sigma^2}{(N-1) B^2/t^2 + \sigma^2}$$

Progress to Date

Milestones reached to date on the cotton project include the following:

1. July 1, 1976 - Established agreement with five large scale farms for use in a special follow-through process. These farmers are acting upon the information provided by the RSC through the ASCS and the Texas Agricultural Extension Service agent, treating their fields and providing the RSC with information concerning crop loss due to the root rot, treatment effect the succeeding year, and an evaluation of the usefulness of the technique to their operation.

2. August 4, 1976 - Acquired the first set of all scales of aerial photos. This marked the beginning of the disease area delineation phase of the project.

3. September 30, 1976 - Acquired the second (last) set of large and medium scale aerial photos as well as the NASA high altitude photos. The interpretation and processing of photo products was underway for the first photo set.

4. October 13, 1976 - Dr. Toler, Dr. Lyda and Mr. Smith of TAMU met with the five cooperating farmers to discuss the disease situation on the five farms. Test fields were selected and procedures defined for taking aerial photography and collecting disease data.

5. December 18, 1976 - Statistical sampling technique tested and accepted for use in determining total diseased acreage in Falls County in 1976 crop year.

6. January 7, 1977 - Overlays completed which constituted the source of the permanent data base for Falls County total cotton area and disease affected cotton area.

Findings

Five Cooperating Farms

Soil sampling locations on the five cooperating farms were chosen on the basis of evaluation of the 1:3,000

scale photography acquired by the RSC. Soil samples were taken both in areas delineated on the photos as diseased and areas not diseased. The samples were 2" x 36" cores which were subdivided to represent six 6" layers: 0-6", 6-12", 12-18", 18-24", 24-30" and 30-36". The samples were analyzed for exchangeable sodium and pH. Table 1 lists the results. High correlation was found in most cases between existence of disease manifestations and relatively lower sodium content. No discernable relationship was found between disease occurrence and pH.

The aerial photos were analyzed to determine the acreage and percent diseased area within each test field. A fine square grid was placed over the aerial photo and the diseased area within each grid block was estimated. The totals for all grid blocks falling within a field represented the diseased acreage for that field. The results are presented in Table 2.

Falls County Coverage

The technique to be used in determining the acreage within Falls County planted to cotton in 1976 and the diseased portion of that acreage has been developed and tested. The technique, using the one-in-k sampling technique described briefly above, is applied on the Bausch and Lomb Zoom Transfer Scope (ZTS) purchased in

Table 1. Analyses of soil from five farms in Bell and Falls Counties where *Phymatotrichum* root rot was (+) or was not (-) manifest. Soil cores (2 x 36") were analyzed for exchangeable sodium and pH.

Farm	Depth inches	Na ⁺		pH	
		(-) ppm	(+)	(-) (+)	(+)
Cobb (Area 5)	0 - 6	219 ^{a/}	70	7.81	7.96
	6 - 12	265	124	7.93	7.87
	12 - 18	482	245	8.04	7.88
	18 - 24	711	492	8.20	8.25
	24 - 30	867	779	8.02	8.54
	30 - 36	1229	1062	8.16	8.28
Collier (Area 2)	0 - 6	91	80	7.83	7.70
	6 - 12	144	93	7.59	7.81
	12 - 18	221	167	7.77	7.73
	18 - 24	376	221	7.91	7.86
	24 - 30	425	311	8.06	7.88
	30 - 36	511	498	7.96	7.87
Ejems (Area 3)	0 - 6	42	35	7.63	7.66
	6 - 12	38	57	7.59	7.69
	12 - 18	48	61	7.66	7.66
	18 - 24	45	47	7.70	7.65
	24 - 30	55	48	7.69	7.79
	30 - 36	74	71	7.92	7.87
Merik (Area 4)	0 - 6	257	72	8.00	8.13
	6 - 12	526	199	8.09	8.02
	12 - 18	729	315	7.88	8.10
	18 - 24	1079	480	8.22	8.12
	24 - 30	1037	719	8.22	8.25
	30 - 36	1600	906	8.02	8.34
Perkins (Area 1)	0 - 6	49	55	7.68	7.49
	6 - 12	33	40	8.04	7.84
	12 - 18	43	49	7.77	7.92
	18 - 24	41	49	7.80	7.66
	24 - 30	45	72	7.57	7.66
	30 - 36	32	64	7.62	7.81

^{a/} Each value is a mean of three samples.

Table 2

Producer	Fld. #	Cotton Total Area (in Acres)	Total Loss to CCR (in Acres)	%Loss
Mr. Shorty Perkins (Area 1)	1A	30.96	1.26	4.07%
Rt. 1	1B	55.26	1.44	2.6%
Chilton, Texas 77632	1C	42.21	4.32	10.23%
Falls County	1D	38.52	7.92	20.56%
	1E	26.64	12.24	45.95%
	1F	23.76	16.57	69.70%
Mr. W.C. Collier (Area 2)	2A	66.24	12.24	18.48%
Rt. 1	2B	36.72	27.36	76.51%
Troy, Texas 76579	2C	63.72	42.84	67.23%
	2D	12.96	11.52	88.89%
	2E	55.08	6.93	12.58%
Mr. Pete Ejems (Area 3)	3A	9.27	1.08	11.65%
Rt. 1	3B	6.12	.90	14.71%
Lott, Texas 76656	3C, 3D	28.8	8.64	30%
	3E	33.3	6.57	19.73%
	3F	12.06	.90	7.46%
	3G	10.98	.90	8.20%
	3H	12.6	.09	.71%
	3I	49.05	.00	.0%
Mr. Kenneth Marek (Area 4)	4A	23.04	8.64	37.5%
Rt. 1	4B	14.4	7.38	54.38%
Burlington, Texas 76519	4C	34.92	12.69	36.34%
	4D	10.44	2.97	28.45%
	4E	18.72	5.76	30.77%
	4F	28.08	5.76	20.51%
Mr. Leonard Cobb (Area 5)	5A	23.40	1.71	7.30%
Rt. 1	5B	80.1	19.8	24.72%
Rogers, Texas 76569	5C	38.16	.36	.94%
	5D	12.42	5.76	46.38%
	5E	17.1	11.52	67.37%
	5F	15.66	9.45	60.34%

part under the NASA grant. Work has begun on the application of the technique to the countywide photography.

Future of the Project

Within the first quarter of 1977, the Falls County 1976 diseased acreage determination will be completed. Application of the sodium salt treatment will also be completed at the five cooperating farms.

The proposed Cotton Root Rot Demonstration Project, begun in a 1976 Applications Project involving five commercial growers and the Texas Agricultural Extension Service, will assess the success of disease control activities and map areas of root rot in the demonstration area not mapped in 1976. Disease control of the soilborne organism does not occur until subsequent years because of the methods used, i.e., sodium salts are added during the off-season in those areas where disease was detected on aerial photos taken during the cotton growing season. Thus, disease control begins in the second year. The Demonstration Project on the five cooperating farms must, therefore, be continued for at least another year in order to assess the effectiveness of control and the ability of the aerial photos to record the associated vegetation changes.

In the 1976 Applications Project, color infrared aerial photography was successfully used by the Remote Sensing Center to provide a permanent record of the diseased areas on five selected cooperating farms. Two counties in Texas, Falls and Bell Counties, were also photographed in order to provide the first quantitative crop loss assessment from this pathogen on a countywide basis.

The five selected farms are utilizing the disease area maps and treatment recommendations provided by the project personnel to apply the chemical controls during the off-season. In addition, these farms will plant cotton next year in the treated fields rather than rotate to sorghum as usual in order that the success of the treatment can be assessed without a year's delay through continuation of the Remote Sensing Center Demonstration Project proposed here.

The Texas Agricultural Extension Service cooperated in the 1976 project and is enthusiastic about the results. County extension agents, Gilbert Wood of Falls County and Donald Decker of Bell County, have established the following plan to be carried out as part of the 1977 Demonstration Project. The Falls and Bell Counties agents, who were familiarized with the project during

1976, will approach the cotton farmers in their counties with the results of the present work. They will work with the Remote Sensing Center to provide the farmers with the delineations of the diseased areas and treatment recommendations.

During the 1977 Demonstration Project, three objectives will be pursued, all through the use of color infrared aerial photography. The first objective will be to make available, in cooperation with the Texas Agricultural Extension Service, diseased area delineations and treatment specifications to all cotton farmers in Falls and Bell Counties. Because of crop rotation (annually alternating between cotton and sorghum), the 1976 and 1977 surveys will provide nearly complete coverage of cotton areas. The second objective will be to assess the success of the treatment applied by the cooperating farms and delineate diseased areas in the cotton fields which had been planted in sorghum in 1976 (sorghum is not adversely affected by the pathogen). The third objective is to provide a crop loss survey for the second year.

The objectives of this Demonstration Project will be accomplished using aerial color infrared photography acquired at high altitude by NASA and at low and medium

levels by the Remote Sensing Center. Diseased area delineation will be done by photointerpretation and transferred to map products through the use of the Remote Sensing Center zoom transfer scope. As in the past, treatment recommendations will be based on soil samples taken from the diseased area identified in the photography. Falls and Bell Counties' extension agents, working with the Remote Sensing Center, will take the information to the farmers.

PEANUT DEFOLIATION AND YIELD ESTIMATION

Background and Objectives

This project is designed to provide data for use in control of peanut foliar disease by a chemical foliage spray program and data for peanut yield estimation. Landsat digital data, ground-based Landsat radiometer data and aerial color infrared photography were acquired of the growing peanut crop to identify those areas infected with peanut foliar disease and to plan for fungicide application. The data are also being used for developing peanut yield estimating models.

Project Demonstration Areas

In this project, as in the Cotton Root Rot Project, the Remote Sensing Center is working through two state agencies, Texas Agricultural Extension Service and Texas Agricultural Experiment Station (TAES) to accomplish the study on commercial fields. The commercial farming study site is located near Poteet in Atascosa County. The TAES Plant Disease Research Station at Yoakum is the small test plot site.

People and Agencies Contacted

The Atascosa County Extension Agent, Mr. Hollis Duke, was briefed on the present project and the previous

work leading to it. He contacted and put RSC and TAES in contact with three farmers who cooperated in the study. They are Mr. J. R. Akers, Mr. G. Payne and Mr. K. Stephens.

Activities to Date

Three levels of fungicide treatment were represented by test sites in the commercial fields arranged through the county agent. These corresponded roughly to the treatment levels available on small test plots at the Plant Disease Research Station, Texas Agricultural Experiment Station, Yoakum, Texas. The ground truth team acquired data at both the Yoakum plots and the commercial fields on the following dates; Poteet - August 13, August 27, September 22 and October 3; Yoakum - August 26, September 21 and October 2. Aerial photography was acquired of the Poteet site on August 22 and September 21. The commercial field basic information on dates, rates of application, yield and other parameters were recorded and supplied by the farmers themselves.

Band 5 B&W Landsat images were acquired for each Landsat overpass from August through the middle of October. These were evaluated for cloud cover. Three sets of CCT's were subsequently ordered on the basis of the image evaluation.

Densitometry has been applied to the aerial photographs of the Poteet commercial fields. All the Landsat radiometer data have been processed to the band ratio parameter (BRP) values and used in statistical regression against defoliation data. The Landsat CCT data are presently being processed. Landsat data will be correlated to the farmers' yield values.

Two conference presentations have been made concerning the peanut project. Both resulted in an abstract being published. The two are given below.

Harlan, J. C., D. H. Smith and R. W. Toler.
1975. Remote Sensing of Peanut Foliar Diseases.
Amer. Phytopath. Soc. Proceedings 2:34.

Hines, R. C., D. H. Smith and J. C. Harlan.
1976. Radiometric Monitoring of Peanut Foliar Diseases. Amer. Peanut Res. and Educ. Assoc. Proceedings 8:92.

Progress to Date

The field measurement program was accomplished as planned at both the Poteet commercial farm area and the Yoakum small test plots. Ground-based Landsat radiometer data have been processed and correlated to defoliation data. Aerial photos were processed and densitometry applied to the Landsat images was evaluated in order to procure the three Landsat CCT sets for correlation with yield data.

Two data analysis steps remain to be accomplished. One is the multitemporal analysis of radiometer data in terms of defoliation and yield. The other is the analysis of the Landsat CCT data in relation to the farmers' yields.

Results

Defoliation vs. Reflectance - Two radiometer band parameters (RBP1 and RBP2) appear to do reasonably well in estimating defoliation percentages: $(\text{band 4} + \text{band 3})/\text{band 2} = \text{BRP1}$, and $(\text{band 4} - \text{band 2})(\text{band 3} - \text{band 2}) = \text{BRP2}$. The R^2 values for the combine 1975 and 1976 data for RBP1 and RBP2 are .51 and .68, respectively (1974 data were not included because of difficulties encountered in obtaining an accurate calibration of the gray panel (Figures 5 and 6)). The rationalization for developing each parameter is the influence defoliation has on reflectance in each radiation band. Plants reflect radiation more strongly in bands 3 and 4 than bands 1 and 2. Reflectance may be as high as 70 percent in band 4 for a healthy crop, 50 percent in band 3 and less than 10 percent in bands 1 and 2. As plants defoliate, reflectance decreases most rapidly in band 4, but remains approximately the same in bands 1 and 2. Given this relationship, a high BRP value implies a healthy crop, while a low value implies a high defoliation percentage.

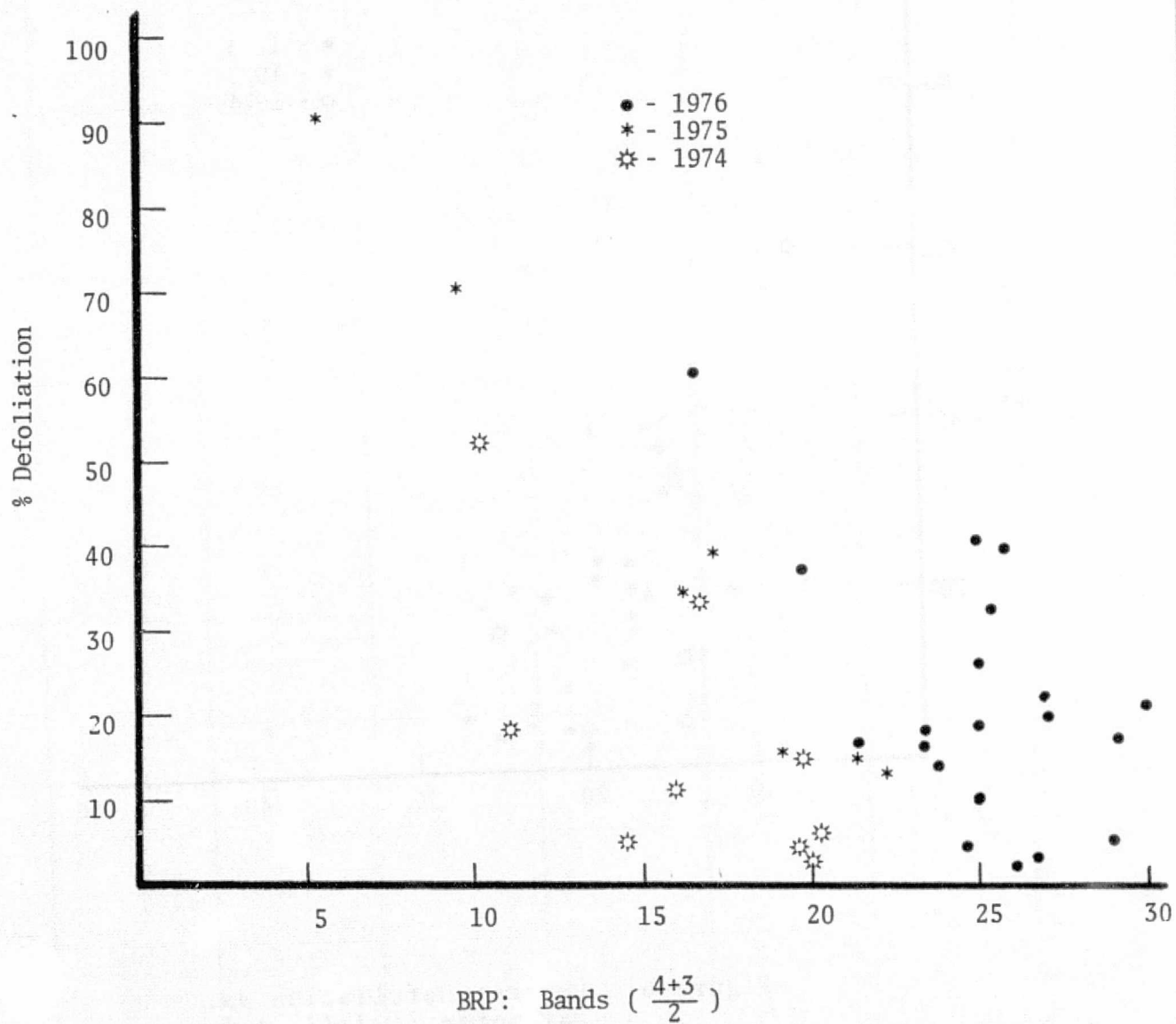


Figure 5. Percent Defoliation vs. BRP for 1974, 1975 and 1976.

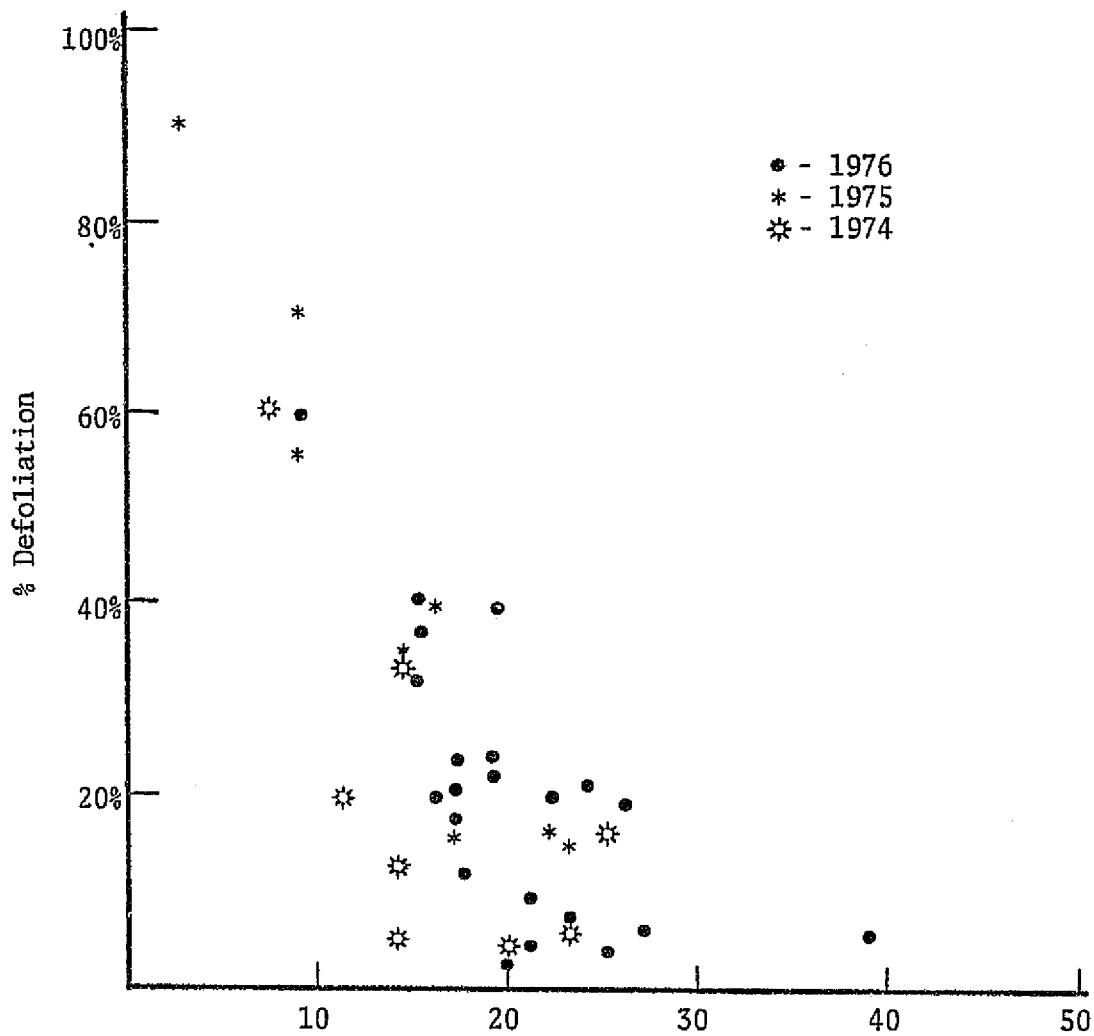


Figure 6. Percent Defoliation vs. Parameter (4-2)(3-2) for 1974, 1975 and 1976.

Defoliation vs. Yield - In 1975, an extensive study was undertaken to analyze the relationship between defoliation and yield. Results show the relationship to be a function of time since defoliation increases through the growth season, i.e., for 9-23-75, the relationship is $\text{Yield} = 4176.35 - 31.81 \times (\text{Defoliation \%})$ ($R^2 = .83$), and for 10-9-75, $\text{Yield} = 42 \times 02.18 - 21.56 (\text{Defoliation \%})$ ($R^2 = .79$) (Figures 7 and 8). Figure 9 shows the relationship between BRP1 and yield for four treatments as a function of time. The 1976 data have yet to be analyzed.

Aerial Photography

Qualitative evaluation of the 1975 aerial photography has shown that treatments are differentiable as defoliation increases during the season. Quantitative analysis via densitometry is underway.

Future of the Project

At the present time, two analysis steps remain concerning the 1976 data. One is the multitemporal analysis of the ground-based radiometer data in relation to defoliation. The second is the single and multiple date analysis of Landsat CCT's relative to farmers' yields. These will be completed within the first quarter of 1977.

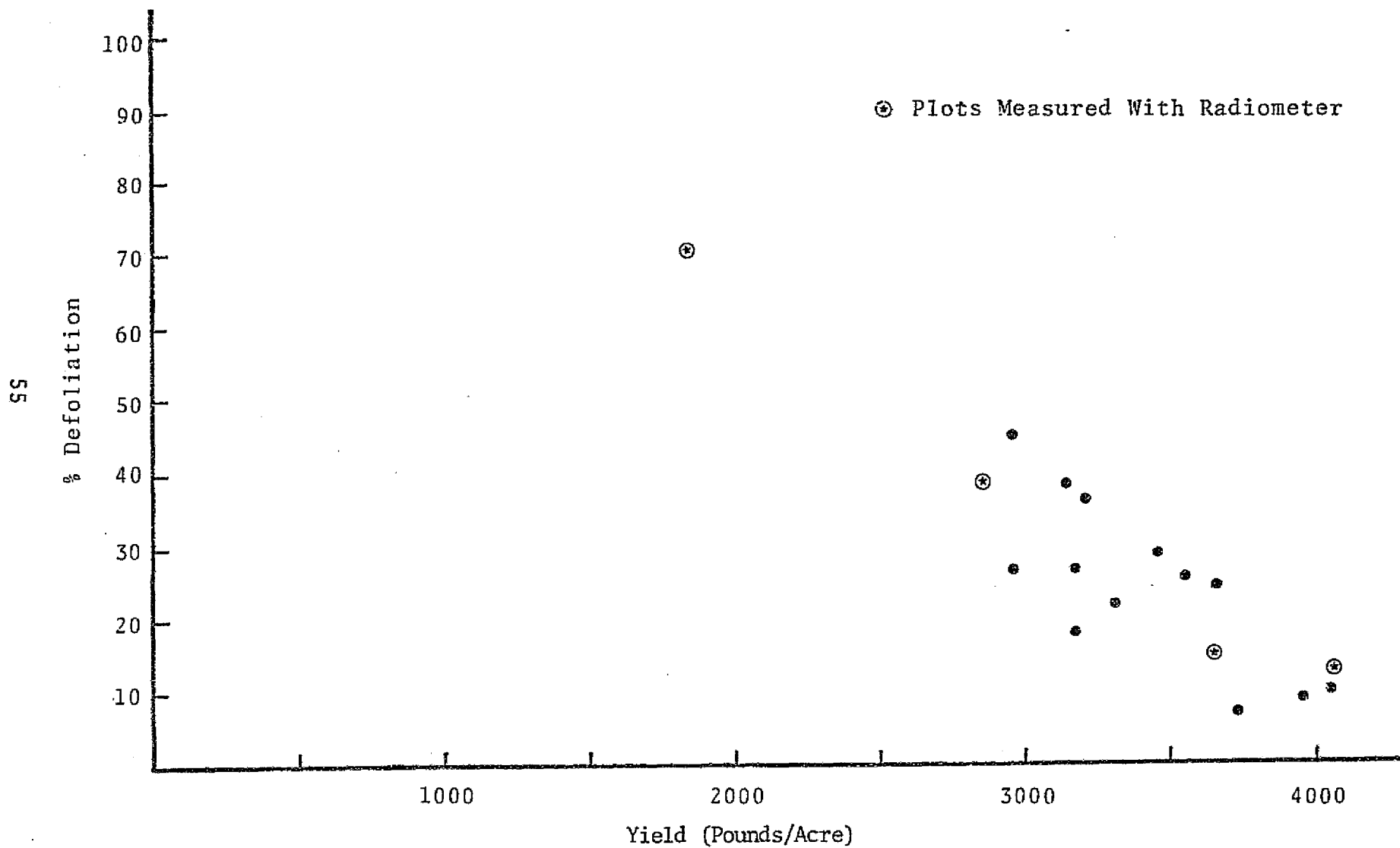


Figure 7. Percent Defoliation vs. Yield. September 23, 1975.

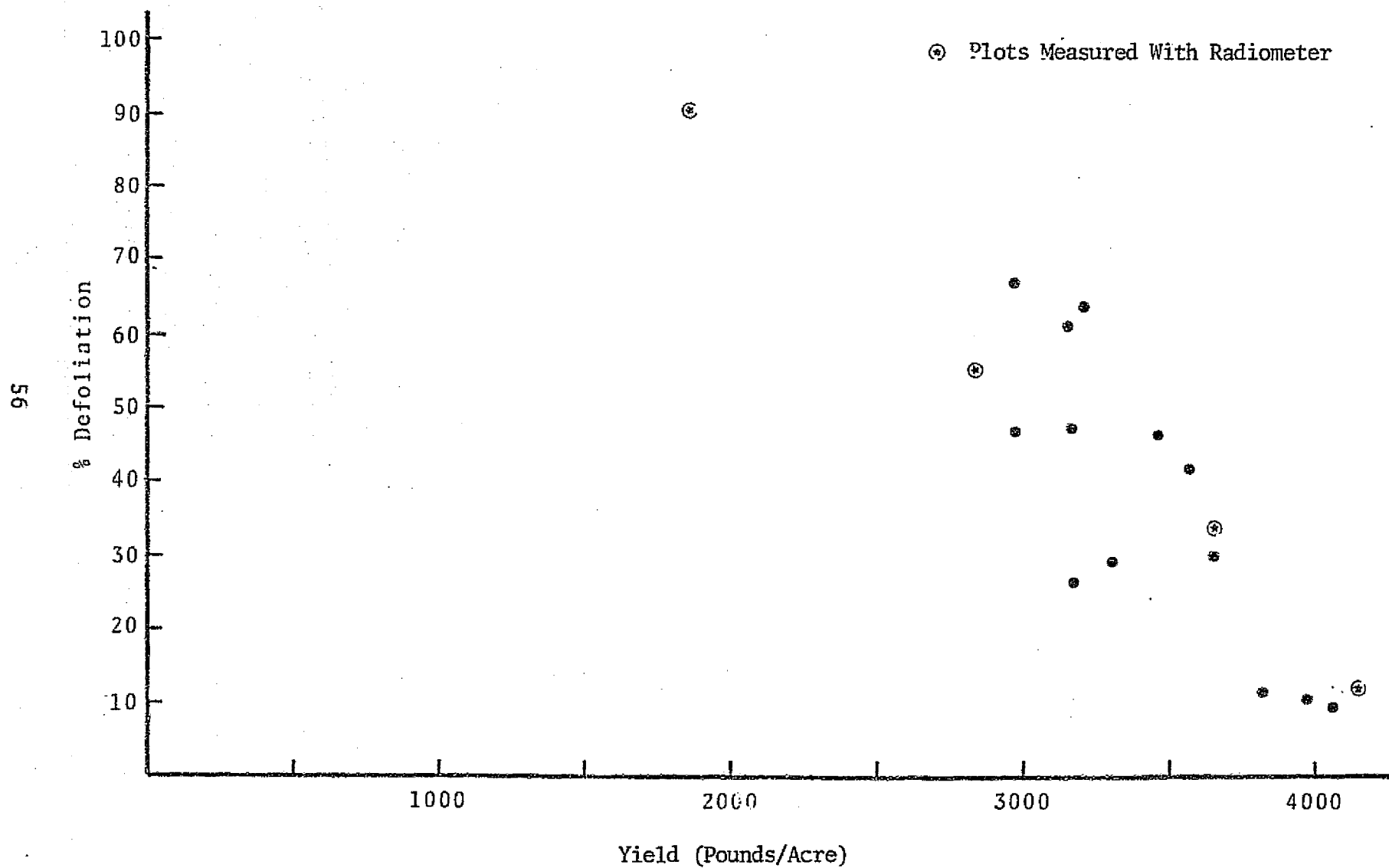


Figure 8. Percent Defoliation vs. Yield. October 9, 1975.

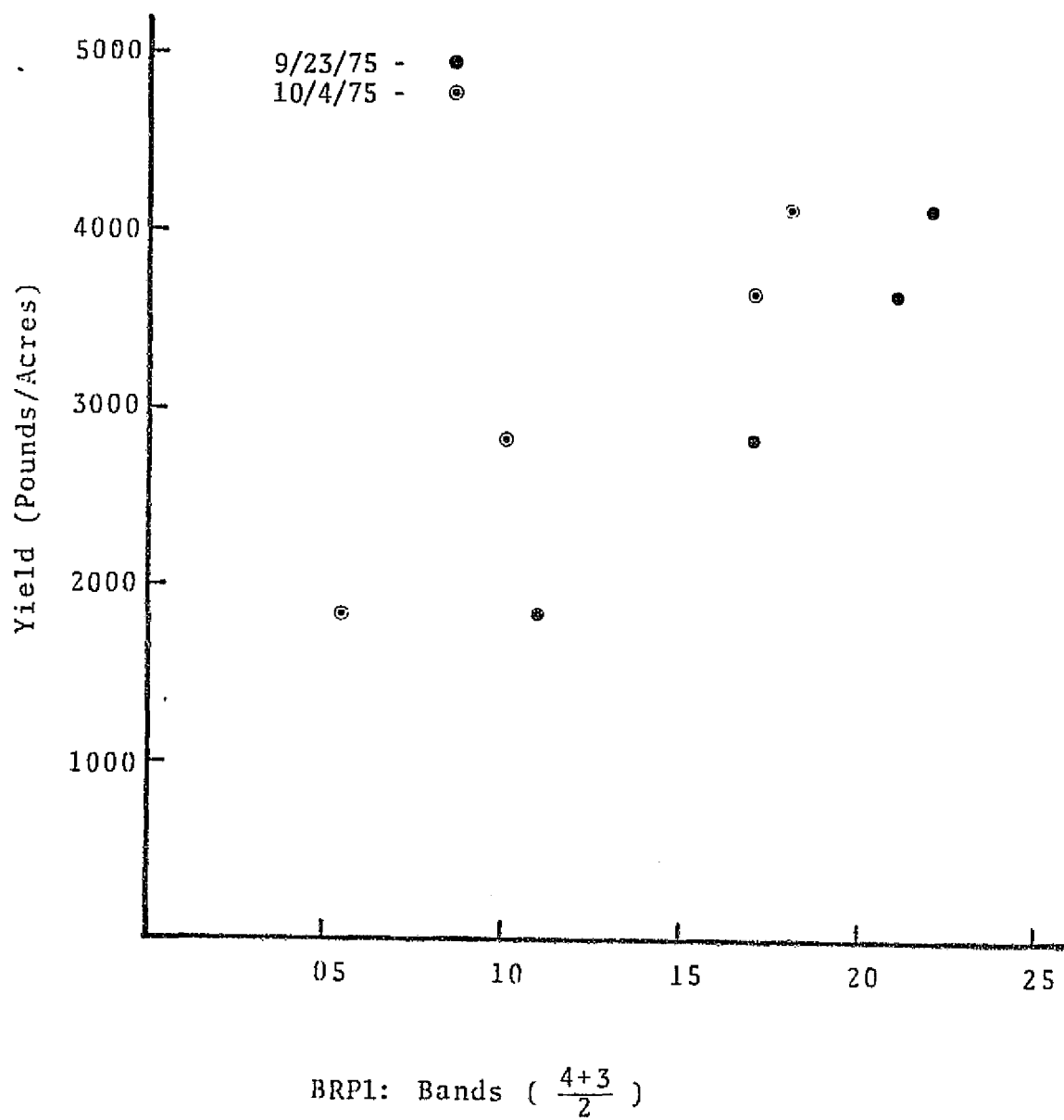


Figure 9. Yield vs. BRP1 with Time as Parameter.

The Texas Agricultural Experiment Station has shown interest in expanding the peanut effort. They point out that much of the peanut acreage in Texas is dryland farmed, however, and is susceptible to drought stress. The experiment remaining to be done before expanding this work into a Demonstration Project, therefore, is a test plot study to develop a technique to differentiate foliar disease effects from drought stress. This experiment, however, is not being continued in 1977 due to limitations in funds for grant projects. Any future Peanut Applications Project should utilize techniques developed during the 1976 Peanut Disease Project to determine the ability of those techniques to detect and discriminate between disease and drought stress occurrences. This work is necessary to enhance the disease assessment by eliminating possible confusion between disease occurrences and drought situations.

CONCLUSION

This annual progress report indicates that significant contributions to the NASA Earth Resource Applications Project have been made by the Texas A&M University grant activity. The NASA grant program objectives have been totally integrated into the grant projects with support for expansion and continuation of the work by cooperating state and federal agencies. A firm base now exists for continued use of the staff assembled for grant activities to respond to new and challenging earth resource applications under the grant program at Texas A&M University.